FARMERS' PRACTICES AND ACCEPTABILITY OF SUPPLEMENTAL IRRIGATION IN BURKINA FASO

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Abstract

This study analyzes the farmers' practices and factors acceptability of supplemental irrigation from small pools of runoff collection (SIPW) on family farms of Sahelian and Sudano-Sahelian zone of Burkina Faso. The farming practices are evaluated using descriptive statistics with data collected from 629 farm households. Acceptability factors are determined through a logistic regression model. The results show that farmers' practices vary depending of the province within the same agro-climatic area. Most of the producers perceive changes in rainfall over the past two decades. The coping strategies are techniques for water and soil conservation, adoption of improved seeds and organic manure. However during dry season, crops remain subject to water stress caused by dry spells. For the majority of farm households, the SIPW is an alternative to mitigate the consequences of the dry spells. The acceptability ratio is estimated between 65 to 94% depending on province of agro-climatic zones. Farmers' decisions to practice SIPW are determined by eleven significant variables. Factors promoting the acceptability of SIPW in agricultural systems are marital status, farmers' perceptions of reduced rainfall events, practice of crop rotation and access to information. Constraints to adopt SIPW are illiteracy, use of improved seeds, farmers' perceptions of the frequency of flooding, expected usefulness of maize, sorghum and vegetables.

Keys words: dry spells technology, adoption, rain-fed crop, dry climate.

Introduction

West African agriculture is mainly rain-fed (Niasse, Afouda, & Amani, 2004) and dependent on weather conditions (GIEC, 2007). Current agricultural techniques adopted by farmers are not effective in stabilizing agricultural production during a 2 to 3 weeks dry spells (Roose, 1993). Supplemental irrigation is an alternative to overcome the water deficit of rain-fed crops in semi-arid areas (Dialla, 2002; Pathak et al., 2009; Rockström et al., 2010).

In general supplemental irrigation of rain-fed crops was tested but it is not popularized in rural areas of Burkina Faso (Some, 1989). However most farmers are in favor of the adoption of innovations disseminated to mitigate the risks of drought (Some, 1989; Ouédraogo et al. 2010). These farmers'

commitment to accept innovations prompted the International Institute for Water Engineering and Environment (2iE) to disseminate supplemental irrigation via basin collecting run-off water (SIPW) in the provinces of Bam and Yatenga through the Project of supplemental irrigation and climate information (PSICI). The Ministry of Agriculture and Water Resources (MAWR) disseminated the practice in 10 of the 13 regions of the country, mainly in the Sahelian and Sudano-sahelian agro-climatic zones through "garden maize". At this point, if we can consider that SIPW is popularized since the 2012-2013 rainy season campaign in Burkina Faso, the question of its acceptability by farmer's remains.

The objective of this research is to determine the susceptibility of farmers to adopt the SIPW while examining its position related to agricultural innovations practiced in family farms. This research is specifically designed to examine the practices of farmers on the one hand, and to identify the determining factors of the acceptability of SIPW on the other.

Study approach

Presentation of the study area

The study was conducted in the Sahelian and Sudano-sahelian areas of Burkina Faso (figure 1). The Sudano-sahelian zone is characterized by rainfall between 900 and 600 mm and a rainy season lasting from 4 to 5 months. In the Sahelian zone, annual rainfall ranges between 300 and 600 mm and are characterized by a very irregular spatial and temporal distribution. The rainy season lasts less than three months.

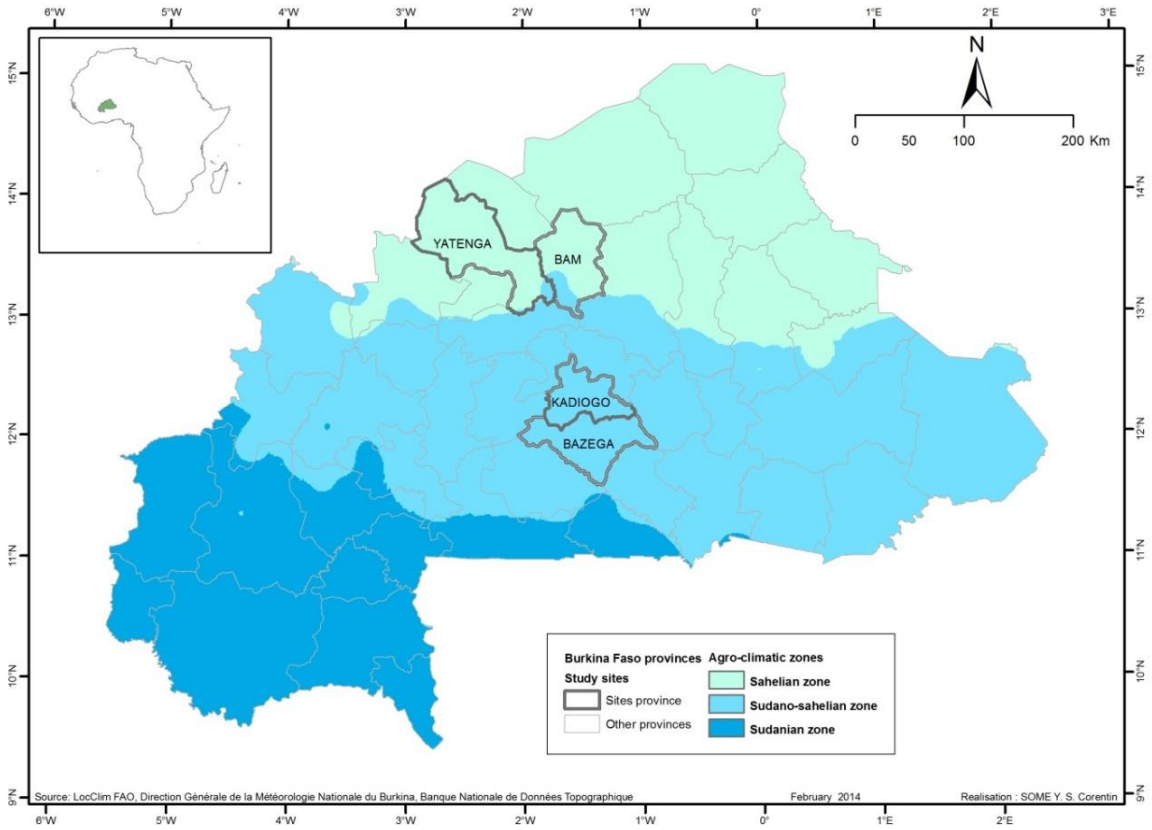

Figure 1. Agro-climatic zones of Burkina Faso and study sites

With less than 70 days of rainfall, the Sahelian and Sudano-sahelian zones are more subject to the so called rainfall deficit because of the dry spells of the rainy season compared to the South-sudanian zone (SP/CONEDD, 2007). Many consider irrigation as a necessity to boost agricultural production and improve food security. The supplemental irrigation of rain-fed crops is practiced at a small scale in several tropical countries (Oweis et al., 2004; Merabeta and Boutiba 2005; He et al., 2007). However SIPW is still a rare innovation among west African farmers on family farms out of irrigation schemes surface especially as the practice remained at the experimental stage (Some, 1989; Fox and Rockström, 2003)

Theoretical frameworks

Methods to analyze the acceptability of agricultural innovations were initially based on models of human behavior borrowed from neo-classical economics. These models can be grouped into three categories. The Theory of Reasoned Action (TAR) reveals that the intention to adopt a technology is

determined by two factors, one reflecting his personal interests and the other his social influence (Ajzen and Madden, 1986). Stemming from TAR, model of technology acceptance indicates that acceptance is mainly determined by two types of perceptions: the perceived usefulness of the system and its perceived ease of use (Davis, 1989). The theory of innovation spreading shows that the perceived value of an innovation depends on relative advantage, compatibility, complexity, trial ability and the way to observe (Rogers, 2003). This theory can be likened to the spread of an epidemic (Richefort and Fusillier, 2010). Alternative of behavior models were then made by economic theory which predicts that faced with a problem of choice, a rational economic agent chooses the option that maximizes his utility (Gourieroux, 1989).

Logistic regression model representing farmer i decision to adopt or reject SIPW is given by the following expression:

$$P = \Phi(\beta X_i) = \frac{Exp(\beta X_i)}{1 + Exp(\beta X_i)}$$

P is the dependent variable taking 1 if adopted and 0 otherwise, β is the vector of parameters to be estimated, X_i is the explanatory variables of farmers and $\Phi(\beta X_i)$ is the probability that the farmer accepts SIPW.

Model specification

For an economic agent, acceptance of innovation refers to a binary variable taking 1 if he adopts and 0 otherwise (Greene, 2011). In this study, the binary variable defines the acceptance of supplementary irrigation (ASI). Dependent variable ASI_i is treated as 1 if the farmer i had accepted SIPW and 0 otherwise. Explanatory variables are related socio-economic characteristics of farmers, their perceptions of drought and interest to the practice of SIPW (table 1). Assumptions have been made on the influence of each of them on the ASI.

Table 1. Definition of explanatory variables

Variables	Variables description	Expected effects
Provinces		
Yatenga (reference)	Membership Yatenga (0=no; 1=yes)	+
Bam	Membership Bam (0=no; 1=yes)	-
Kadiogo	Membership Kadiogo (0=no; 1=yes)	-
Bazega	Membership Bazega (0=no; 1=yes)	-
Socio-economic characteristics		
Marital	Marital situation (0 = single; 1 = married)	+
Education	Level of education (0 = illiterate; 1= literate)	+
Age	Age of household head (0= old ; 1 = young (age < 45)	+
Size	Size of the farm household	+
Labor	Family labor	+
Organization	Membership to a farmer organization	+
Land	Mode of access to land (0=other; 1=heritage)	+
Access	Access to technical services (0=no; 1=yes)	+
Transport	Possession of transport equipment (0=no; 1=yes)	+
Income	Farm income	+
Off-income	Off-farm income	+
Farmers' perceptions of dry spells		
Stable	Stable evolution of dry spells (0=no; 1=yes)	-
Decrease	Decrease evolution of dry spells (0=no; 1=yes)	-
Increase (reference)	Increase evolution of dry spells (0=no; 1=yes)	+
Alternative	Evolution chisel dry spells (0=no; 1=yes)	
No answer	No answer about dry spell's evolution (0=no; 1=yes)	-
Adoption of agricultural innovations		
Bunds	Use of stone bunds (0=no; 1=yes)	+
Mulching	Practice of mulching (0=no; 1=yes)	+
Moons	Practice half-moons (0=no; 1=yes)	+
Dikes	Use of small dikes (0=no; 1=yes)	+
Diversification	Diversification of crops (0=no; 1=yes)	+
Manure	Use of organic manure (0=no; 1=yes)	+
Rotation	Practice of rotation (0=no; 1=yes)	+
Seeds	Use of improved seeds (0=no; 1=yes)	+
Zaï	Practice of zaï (0=no; 1=yes)	+
Farmers' perceptions SIPW		
Intend	See or heard of SIPW since 2012 (0=no; 1=yes)	+
Information	Sources of information (0= radio ; 1 = farmers)	+
Maize (reference)	Useful for the cultivation of maize (0=no; 1=yes)	+
Sorghum	Useful for the cultivation of sorghum (0=no; 1=yes)	+
Millet	Useful for the cultivation of millet (0=no; 1=yes)	+
Rice	Useful for the cultivation of rice (0=no; 1=yes)	+
Vegetable	Useful for the cultivation of vegetables (0=no; 1=yes)	+
Ignore	No answer for appropriate crops	+
Cost	Construction cost of the basin	-

+ : expected positive effect; - : expected negative effect

Data collection

Data collection was performed on the basis of stratified sampling at three levels chosen in collaboration with the team of PSICI and provincial direction of MAWR. Different levels are the

provinces, villages and farmers (figure 1). The number of farmers per village was obtained with the basis of updated data from the permanent agricultural survey of the MAWR. From this base, 629 farmers spread over eleven villages were surveyed from January to February 2013 in the provinces of Yatenga Bam Kadiogo and Bazega. In each village, a third of farmers were randomly surveyed.

Results

Socio-economic diversity of farmers

Table 2 presents the socio- economic characteristics of the farmers sampled. In the province of Bam, the heads of households are educated (48.5%), organized (41.5%), young (71.9%) and derive more income from agriculture (CFA 99685.60 ± 9984.17 Francs) compared to those in other provinces. The proportion of married man among farmers is higher in Kadiogo (98%). Farm size of (16) and the assets number (6) are higher in Yatenga. Therefore these farmers have a good access (9.70 %) to supervision by agricultural services. Low levels of equipment carts (35.0 %) and off-income (CFA 76,285.71 ± 14,536.02 Francs) were observed in the Bazega. In general socio-economic characteristics are significantly different within and between agro-climatic zones ($p < 5\%$). Only off-farm incomes are similar ($p > 10\%$).

Table 2. Socio-economic characteristics of farm households

Agro-climatic zones	Sahelian		Sudano-sahelian		p-value
Provinces	Yatenga	Bam	Kadiogo	Bazega	
Age of the head					0.000
Young (%)	51.4	71.9	62.4	47.0	
Old (%)	48.6	28.1	37.6	53.0	
Marital Status					0.037
Not married (%)	4.3	9.5	2.0	6.8	
Married (%)	95.7	90.5	98.0	93.2	
Education					0.001
Illiterate (%)	61.4	51.5	59.8	74.4	
Literate (%)	38.6	48.5	40.2	25.6	
Organization					0.000
No (%)	62.4	58.5	91.2	88.0	
Yes (%)	37.6	41.5	8.8	12.0	
Land					0.000
No (%)	20.0	1.0	2.90	0.9	
Yes (%)	80.0	99.0	97.1	99.1	
Access					0.000
No (%)	90.3	96.5	95.6	98.8	
Yes (%)	9.7	3.5	4.4	1.2	
Transport					0.000
No (%)	61.0	63.8	46.4	65.0	
Yes (%)	39.0	36.2	43.6	35.0	
Size	16.12±0.84	10.81±0.41	8.43±0.37	9.74±0.54	0.000
Labor	6.21±0.54	4.21±0.23	3.44±0.16	4.62±0.30	0.000
Income (CFA Francs)	62,090.90± 3,151.98	99,685.60± 9,984.17	59,562.06± 2,735.96	41,341.60± 4,257.28	0.000
Off-income (CFA Francs)	198,992.01± 31,039.34	247,112.50± 34,176.83	153,719.30± 33,677.51	762,85.71± 14,536.02	0.214

Adoption of agricultural innovations against dry spells

Several agricultural innovations were adopted by farmers to mitigate the impact of dry spells (Table 3). The adoption of organic fertilizer rate is above 50% in all provinces. In the Yatenga and Bam provinces which are located in the Sahelian zone, zaï is adopted by 53.3% and 94.5% compared to 6.9% and 0.9% for the Kadiogo and Bazega provinces located in the Sudano-sahelian zone. However the rotation of crops is practiced by 97.1% in the Kadiogo, 93.2% in Bazega compared to 33.3% in Yatenga and 6% in Bam. Over 80% of farmers use stone bunds in all provinces except Bazega (17.1%). Half-moons adoption is low practiced in all provinces. The rate of tillage practice and crop diversification is higher than 50% in Kadiogo, Bazega and Yatenga compared to less than 12 % in Bam. The rate of the use of improved seeds is between 22% and 71.6% in all provinces. Farmers

adopting the filter bunds are less than 2% in all provinces except in Bazega where they reach 30.8%. Except for half-moons, the adoption of innovations varies significantly among provinces ($p < 0.001$).

Table 3. Adoption of agricultural innovations

Agro-climatic zones	Sahelian		Sudano-sahelian		p-value
Provinces	Yatenga	Bam	Kadiogo	Bazega	
Zaï (%)	53.3	94.5	6.9	0.9	0.000
Bunds (%)	72.9	88.5	80.4	17.1	0.000
Moons (%)	1.4	1.0	0.0	0.0	0.402
Dikes (%)	1.0	1.0	0.0	30.8	0.000
Diversification (%)	51.4	11.0	96.1	96.6	0.000
Mulching (%)	7.1	2.5	20.6	1.7	0.000
Rotation (%)	33.3	6.0	97.1	93.2	0.000
Seeds (%)	42.9	28.5	71.6	22.2	0.000
Manure (%)	96.7	94.5	68.6	97.4	0.000

Acceptability factors of SIPW

The results of the econometric regression are statistically valid. Indeed the prediction percentage (80.89%) and the log-likelihood (-431.550) are satisfactory. Chi-square model (Prob > chi2 = 0.000) is significant at 1% and a correlation exists between variables (Pseudo $R^2 = 0.295$). Depending on the values of p-value, the parameters of model show that among 35 variables uncorrelated 16 variables determine significantly the occurrence of ASI.

Socio- economic variables such as marital status, age of the head of household, household size, and number of active peasants, equipment and farm income significantly affect the ASI (Table 7). Variables that positively impact the ASI are household size at1%, farm income at 5% but also transport and marital threshold of 10%. In contrast the variables age and assets affect the respective ASI threshold of 5 % and 1 %. These results show that the SIPW is likely to be accepted by the household size, the married man, farmers with a cart and farmers with agriculture as the main source of income. But the young heads of households and the majority of active peasants are not available to integrate it into their farming systems.

Among the variables related to farmers' perceptions of dry spells, the lack of farmer perception of the evolution of dry spells negatively influences the ASI at threshold of 5%. This result shows that

farmers without perception of changes in the frequency of dry spells are less likely to adopt the SIPW than farmers who perceive an increase, decrease, stability or alternating of dry spells.

Among the variables related to agricultural innovations already adopted, stone bunds, mulching, diversification, seeds, half-moons and zaï significantly affect the ASI. Stone bunds and seeds positively impact the ASI at risk threshold of 1%, while the mulching is at 5%. But, half- moons and zaï are variables which affect the ASI threshold of 10%. The adoption of bunds, mulching and use of improved seeds encourage farmers to practice SIPW contrary to the practice of zaï, half- moons and crop diversification.

Moreover access to information on irrigation and ignorance of the most suitable crop (without notice) are variables affecting the ASI. Access to information promotes ASI at risk threshold of 1% while ignorance of the appropriate culture affects the risk by 1%. Farmers aware of the practice of SIPW have a propensity to SIPW while farmers unable to identify suitable crops are not.

Variables in Kadiogo and Bazega positively influence the ASI threshold by 1%. In contrast the variable as Bam affects the threshold by 1%. These results show that the propensity of farmers to practice SIPW is similar in the provinces of Yatenga, Kadiogo and Bazega. However this tendency is low in Bam.

Discussion

Current practices of farmers within and between climatic zones

The analysis of farmers' practices shows that the adoption of agricultural innovations is heterogeneous within and between the Sahelian and Sudano-sahelian climatic zones in Burkina Faso. These results are consistent with the results of several previous studies indicating that this heterogeneity is due to the combination of several socioeconomic factors (Kebede et al., 1990; Ashok and Sasikala, 2012). According to Sidibe (2005), farmers' education and their perception of land degradation promote the adoption of the zaï technique while belonging to a peasant organization facilitates the adoption of

bunds in the Sahelian zone. For Ouedraogo et al. (2010), household access to agricultural services explains the use of improved seeds.

Table 4. Summary of explanatory variables

Variables	Ratio	Standard errors	z	P>|z|
Provinces				
Bam**	-1.070	0.367	-2.920	0.004
Kadiogo**	1.425	0.532	2.680	0.007
Bazega**	1.660	0.527	3.150	0.002
Socio-economic characteristics				
Marital*	0.582	0.342	1.701	0.088
Education	0.095	0.185	0.516	0.609
Age**	-0.561	0.194	-2.903	0.004
Size***	0.089	0.023	3.854	0.000
Farm laborer***	-0.109	0.030	-3.611	0.000
Organization	0.288	0.208	1.386	0.166
Land	0.557	0.426	1.319	0.191
Transport*	0.348	0.191	1.820	0.069
Access	0.627	0.559	1.127	0.262
Income**	0.000	0.000	2.761	0.006
Off-income	0.063	0.044	1.433	0.154
Farmers' perceptions of dry spells				
Stable	-0.181	0.319	-0.731	0.374
Decrease	-0.277	0.324	-0.868	0.392
Alternative	0.277	0.254	1.095	0.277
No answer*	-1.216	0.590	-2.062	0.039
Adoption of agricultural innovations				
Bunds***	0.929	0.253	3.679	0.000
Mulching**	1.145	0.572	2.001	0.045
Moons***	-1.598	0.931	-1.725	0.086
Dikes	0.410	0.456	0.906	0.368
Diversification**	-0.776	0.284	-2.730	0.006
Manure	-0.276	0.416	-0.664	0.508
Rotation	-0.270	0.283	-0.956	0.341
Seeds***	1.305	0.247	5.298	0.000
Zaï *	-0.573	0.313	-1.832	0.067
Farmers' perceptions of SIPW				
Intend ***	1.108	0.221	5.021	0.000
Sorghum	0.489	0.315	1.550	0.120
Millet	0.356	0.398	-1.454	0.371
Rice	-	-	-	-
Vegetable	-0.908	0.627	0.899	0.148
Ignore***	-2.017	0.294	-6.867	0.000
Cost	-	-	-	-
Constant	-7.828	4.246	-1.841	0.065

Number of observations : 629 ; Percent correct= 80.89% ; LR chi2(32) = 360.651;
Prob > chi2 =0.000 ; Pseudo R^2 = 0.295; Log likelihood = -431.550;

* significant at of 10 %; ** significant at 5 %; *** significant at 1 %.

Furthermore the heterogeneity at the adoption of agricultural innovations could also be explained by differentiated perceptions of farmers about dry spells within and between the Sahelian and Sudano-Sahelian zones. This result goes in the same analysis as that of Brou et al. (2005) who found that the adoption of some practices in the agro-climatic regions of Côte d'Ivoire was induced by their perceptions of climate hazards. Other studies in Benin also indicate the dependence of agricultural practices depending on farmers' perceptions of climate change (Smit et al., 1996; Deressa et al., 2008; Baudoin 2010). Despite farmers' strategies, yields of rain-fed crops are still experiencing drastic declines linked to dry spells (MAH, 2012). Faced with this situation more than 65% of the farmers believe that SIPW is an effective strategy.

Acceptability factors of SIPW

The results show that farmers have differential acceptance of the SIPW. The size of the farms, the heads of married households and the farmers' mainly relying on agricultural income are willing to practice SIPW. They are unanimous that this new innovation will not only help stabilize yields of rain-fed crops facing dry spells but also diversify their sources of income through the practice of vegetable crops during the rainy season. In contrast, young heads of households and most active farmers are not interested in the practice of SIPW. They are more oriented towards non-agricultural activities including gold mining which can provide substantially more cash income than agriculture in some northern region of Burkina Faso (Thune, 2011).

Unlike the adoption of zaï and crop diversification, adoption of bunds and the use of improved seeds induce farmers to irrigate rain-fed crops. Producers believe that the zaï and crop diversification will minimize the adverse effects of dry spells yields similarly to SIPW. They think that it is no longer necessary to perform supplemental irrigation whenever zaï and diversification are practiced. However they recognize the need for SIPW when opting for the use of improved seeds varieties to increase agricultural yields. Improved varieties can improve crop yields only when water is made available to crops (Brocke et al., 2013). Farmers believe that irrigation is still useful in fields where mulching is practiced and where farm bunds are located, since these innovations do not maintain soil moisture for

a long time. According to Zougmore et al.(2004), bunds are recommended to reduce erosion rather than maintain soil moisture.

Farmers who perceive an increase, decrease, alternating and also stability of dry spells have a better propensity to adopt the SIPW compared to other farmers. They believe that the practice of SIPW can increase crop yields. But farmers unable to perceive the evolution of dry spells are uninterested in the practice. The attitude of these farmers could be explained by ignorance of the importance of SIPW for the stabilization or growth of agricultural yields. This ignorance is due to the lack of awareness and lack of training. Indeed the majority of farmers are only informed about the practice of SIPW by word of mouth. The inaccessibility to the media and agricultural services explains this situation. According to Munshi (2004), the mode of information by neighbors does not impulse the adoption of new agricultural innovations.

In addition more farmers of Yatenga, Kadiogo and Bazega are practicing more supplemental irrigation compared to those of Bam. Differentiation susceptibility of farmers to practice SIPW within and between agro-climatic zones could be explained not only by their socio-economic characteristics, types of innovation adopted but also their perceptions of dry spells and especially the information asymmetry.

Conclusion and policy implications

This study analyzes the link between farmers' practices, characteristics and the acceptability of supplemental irrigation in farming systems subject to long dry spells during the rainy season. It showed that farmers have different socio-economic characteristics, rates of adoption of agricultural innovations and heterogeneous perceptions of the development of dry spells within and between Sahelian and Sudano-sahelian Burkina Faso. To mitigate these dry spells, most farmers believe that the practice of SIPW is an alternative. Over 65 % of farmers are planning to use rain-fed irrigation from basin collecting run-off water. Large households, heads of married households, farmers' mainly relying on agricultural income are willing to practice SIPW. Farmers able to appreciate the variation of

dry spells are also more likely to adopt SIPW. But the young heads of households and most active are uninterested in the practice; because they are geared towards non-agricultural activities. Furthermore the use of bunds and improved seeds induces farmers to irrigate rain-fed crops while the practice of zaï and crop diversification does not. Lack of awareness is a major constraint to popularize SIPW. Most farmers are only aware of the practice of SIPW by word of mouth. Measures oriented towards training and sensitization of farmers must be taken to facilitate the adoption of the SIPW in farming systems taking into account the specificities of the agro-climatic zones.

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